

PNM Response to BART Analysis Questions from NMED

The purpose of this document is to respond to the questions and comments that have been received from the NMED in regards to San Juan Generating Station's BART submittal.

This document is organized in the following manner:

- Section 1.0 – Explanation of Cost Development
- Section 2.0 – Discussion of \$/ton Metric
- Section 3.0 – Response to National Park Service Letter dated August 16, 2007.
- Section 4.0 – Response US Forest Service Letter dated August 23, 2007.

We trust that this document fully addresses the open issues associated with the BART for San Juan Generating Station (SJGS). However, please contact PNM with any additional questions.

1.0 Explanation of Cost Development

This section will provide an explanation of how the Selective Catalytic Reduction (SCR) costs were developed.

1.1 SCR Arrangement Overview

The SCR technology for all the SJGS units would be located downstream of the existing ESPs. The ESP's will be de-energized after the installation of the fabric filters, which are being installed in response to the Consent Decree. While the particulate levels entering the SCR's will be somewhat lower than those found on a typical high dust SCR, the SCR's would not be considered a "low dust" SCR because the particulate levels are too high.

The SJGS units fire fuel oil instead of natural gas during startup. Units firing fuel oil have some negative impacts on the SCR's. First, fuel oil firing during startup often results in incomplete combustion. As a result, unburned fuel oil or unburned carbon can enter the SCR unit. Because the SCR catalyst is an oxidation catalyst, unburned materials that are deposited on the catalyst can ignite and cause catalyst fires. Second, the fuel oil sulfur content is relatively high compared to natural gas. During start up, the flue gas remains below the acid dew point for extended periods of time while the ductwork and boiler warms up. If the catalyst is exposed to this cold flue gas for more than a few hours, the acid condensation on the catalyst will damage and shorten the catalyst life significantly. For this reason, an SCR bypass was included in the cost of the project. The installation of a bypass involves adding SCR inlet, outlet and bypass dampers, the associated control system and auxiliaries, and additional ductwork to allow the SCR to be bypassed during startup. This design criteria is applicable to the SCR for each unit at SJGS.

Another plant issue that has significant impacts on the cost is the need for a balanced draft conversion on each of the boilers. The boilers were originally designed for forced

draft operation. Since a fabric filter is being added as a result of the consent decree, the existing booster fans are being modified to handle the additional pressure drop required for the fabric filter. The expected pressure drop is approximately six inches (in. wg) added to the draft system in each unit. Due to the fabric filter work, all the available pressure capacity that can be obtained from the booster fan modifications has been accounted for. If an SCR is required in addition to the fabric filter, fan draft capacities would need to be further increased. For the purposes of the BART analysis, it was assumed that 10 inches of pressure drop would be needed for each SCR and is based on previous experience with SCR projects. The added pressure drop needed for SCR's can range from 8 inches to 12 inches, depending on the duct layout, the amount and type of catalyst provided, and the type of flow distribution devices used. 10 inches was selected as an average value of this industry range. To increase the fan capacity by this amount, the forced draft (FD) fans could be modified, but this would result in an even higher pressure within the boiler which will cause increased ash/soot leakage around the boiler area and likely require stiffening of the boiler walls due to NFPA requirements. A better and less costly alternative is a new ID fan system which would result in the "zero pressure point" (the point after which flue gas flows on a negative pressure) being moved farther upstream, probably within the convection pass of the boiler. Therefore, a balanced draft conversion was included, where the majority of the pressure rise is done across the ID fans. Conversion to balanced draft operation would require new ID fans, a more efficient motor for the existing FD fans, and boiler stiffening.

1.2 Explanation of Individual Cost Line Items

This portion of the document describes how the costs were developed for each line item. B&V often uses a "scaling factor" to determine pricing for the evaluated unit based on a reference pricing from a reference unit. This is an accepted and widely used practice in engineering design. The scaling factor is a standard engineering tool used in high level estimates. The cost of equipment is not directly proportional to the unit size. Smaller units will have relatively higher costs than larger units. This is because some items, such as bearings, seals, electrical equipment, monitoring equipment, transmitters, etc., cost the same, regardless of the unit size. A lower scaling factor is used if the cost of equipment is less proportional to the unit size, while a higher scaling factor is used if the cost of equipment is more proportional to the unit size. For the cost of equipment evaluated at SJGS, it was determined that a 0.6 scaling factor can be used to approximate the relationship between the evaluated and reference unit size, when determining the cost of equipment. The equation used for scaling is as follows:

$$Equipment_Cost_{evaluated_unit} = \left(\frac{Size_{evaluated_unit}}{Size_{reference_unit}} \right)^{0.6} \times Equipment_Cost_{reference_unit}$$

Previously PNM provided an annotated version of the cost tables on July 11, 2007 in response to questions from the National Park Service (NPS). The annotated tables explain how each line item in the cost estimate was developed. The annotated tables

have been enclosed again in Appendix A. There are a few items in the response to the NPS that should be re-emphasized:

- Construction Indirects. A labor market review was performed as part of these estimates. Currently, the construction market for air quality projects and new coal generation projects is very competitive. There are a large number of projects in progress, resulting in serious competition for skilled construction labor. As a result, the construction industry is finding that it is necessary to pay overtime to all construction staff in order to attract enough labor to do the project. The result is overtime paid at time plus ½. The cost of this additional salary is included in the construction indirects.

In addition, because of the tight labor market, the quality of the construction labor has dropped as more people (with less experience) take jobs to fill in the demand. The reduction in productivity is included in the construction indirects.

Finally, because San Juan Generating Station is located in a somewhat remote location and there is direction competition with construction activities at the Four Corners Plant, it is required that per diems be paid to construction labor to pay for living expenses and relocation costs.

- Emissions Testing. The yearly emissions test for the SCR is to check the ammonia injection system of the SCR. Since catalyst degrades over time, the ammonia distribution at the outlet of the catalyst can change dramatically over the course of a year. As a result, SCRs require yearly emissions testing of ammonia and NO_x to determine what adjustments are needed to the ammonia injection grid to keep the unit NO_x emissions in compliance within the applicable limits. The ammonia injection grid is equipped with valves that can be adjusted to reduce or increase ammonia injection through each of the nozzles.

The testing included in the estimate is the yearly testing and is not the same as any performance or RATA testing required by the air permit. The permit testing would be done at the stack while the yearly emissions testing for the SCR would be done at the inlet and outlet of the SCR.

- Catalyst Life. Since there is no SCR experience with San Juan's fuel within the industry, B&V assumed a short catalyst life. Other western fuels have caused some SCR suppliers to limit catalyst life to two years. It should be noted, however, that if the catalyst life were increased to a larger value (for example, three years), the catalyst volume (and therefore the cost of the catalyst) would also need to increase to account for the fact that the catalyst has to make it through a longer period of time while maintaining the guaranteed performance. As a result, the impact on annual cost is fairly minimal if the catalyst life were to be increased.

1.3 Impact of Balanced Draft Conversion and SCR Bypass Dampers

Questions have been raised about the high costs shown in the B&V estimate for SCR. There are three items in the cost estimate that are resulting in elevated costs for the SCR's. Those items are as follows:

- Balance draft conversion
- SCR Bypass
- Construction Indirects

As described in Section 1.1 of this document, the SCR for SJSG will require a balance draft conversion and SCR bypass dampers. These two items have a significant impact on the cost associated with the project and are required if SCR is to be considered as a technically feasible option. In order to illustrate the impact of these items on the cost of SCR for SJGS, Table 1-1 has been produced.

As can be seen by this table, the cost of SCR for SJGS would be very similar to other SCR project costs if the balance draft conversion and SCR bypass were not required.

The third item that is elevating the cost of SCR is the construction indirects. As stated in Section 1.2, the construction market is very volatile right now, resulting in high costs for all retrofit projects. This additional consideration of actual cost impacts in a construction project is necessary to reflect the actual cost of the labor market. By performing this evaluation, the actual cost impact due to the situation with the construction labor market is captured, which results in a cost estimate that is more reflective of the actual project costs if it were to be implemented, when compared to the resultant cost estimates of other cost models which do not evaluate the construction indirect to the same level of detail. As a result, it is important to reflect this knowledge in the cost estimating that we have performed.

Table 1-1 Impact on the Price of SCR from Balance Draft Conversion and SCR Bypass			
	Capital Cost (1,000\$)	Annual Cost (1,000\$/yr)	Cost Effectiveness (\$/ton)
Unit 1			
SCR with Balanced Draft and SCR Bypass	156,805	20,525	6,466
SCR w/o Balanced Draft Conversion	119,603	16,500	5,198
SCR w/o Balanced Draft Conversion and SCR Bypass	75,176	11,495	3,621
Unit 2			
SCR with Balanced Draft and SCR Bypass	169,251	21,891	6,932
SCR w/o Balanced Draft Conversion	132,485	17,909	5,671
SCR w/o Balanced Draft Conversion and SCR Bypass	85,037	12,576	3,982
Unit 3			
SCR with Balanced Draft and SCR Bypass	215,568	28,359	5,752
SCR w/o Balanced Draft Conversion	164,309	22,854	4,635
SCR w/out Balanced Draft Conversion and SCR Bypass	116,857	17,520	3,553
Unit 4			
SCR with Balanced Draft and SCR Bypass	199,558	26,592	5,497
SCR w/o Balanced Draft Conversion	148,299	21,086	4,359
SCR w/o Balanced Draft Conversion and SCR Bypass	103,876	16,081	3,324
Note: 1. Annual cost (1,000\$/yr) includes cost for capital recovery. 2. Balanced draft conversion and SCR bypass are required for the SCR to be considered as a technically feasible option. 3. “SCR w/o Balanced Draft Conversion” and “SCR w/o Balanced Draft Conversion and SCR Bypass” case shown for illustration/comparison purposes only.			

2.0 Discussion of the \$/ton Metric

During the recent discussion with NMED regarding the BART analysis for the San Juan Generating Station, NMED indicated that they intend to use the \$/ton metric as a primary metric for determining BART. Although PNM acknowledges that \$/ton metric is frequently used as part of the BACT analysis for PSD permits, it is not appropriate to rely solely on this metric when assessing BART.

The purpose of BART is to determine the impact to visibility in surrounding Class 1 areas. Therefore, the visibility improvement and the cost effectiveness in dollars per deciview (\$/dv) for achieving the visibility improvement must be a key part of the analysis. Using the dv information only as a metric for screening purposes is inconsistent with the basic reasoning for performing the BART analysis in the first place.

Table 2-1 shows the results of recent NO_x BACT analyses for new coal-fired units. The data were obtained from public records.

Table 2-1 SCR Cost Effectiveness - New Unit BACT Results				
Unit	State	Application Date	Emission Rate	\$/ton
Sunflower - Holcomb	KS	Feb-06	0.07	2,887
Longleaf	GA	Feb-06	0.07	1,500
AECI	MO	Jan-06	0.07	2,140
Toquop Energy Project	NV	Feb-07	0.06	4,300

As can be seen by these results, the \$/ton levels for the SJSG BART analysis are significantly higher than the BACT results. This is mainly because a new unit will not face the challenges of retro-fitting an SCR on an existing unit as discussed in Section 1.0.

3.0 Response to National Park Service Letter

This portion of the document will provide responses to some of the comments made by the National Park Service (NPS) in their letter dated August 16, 2007. The responses are grouped by subject.

3.1 Regulatory Status of the Consent Decree

The NPS letter implies that PNM is attempting to override the BART process with the consent decree. This is definitely not the case.

Emission controls required by the consent decree are currently in the process of being installed on Unit 4. The controls will be installed on Unit 3 starting in early 2008, on Unit 1 in September of 2008, and Unit 2 early 2009 to meet the required compliance dates. Equipment has been designed and purchased for all units. The consent decree work will occur irrespective of BART. PNM did model the existing conditions at the site.

However, because the Low NO_x Burners and Overfire Air (LNB/OFA) retrofit and the particulate control retrofit are already in progress, the BART analysis would not accurately reflect the very near future conditions at the plant without discussing and analyzing the consent decree control technologies associated costs and expected emission reduction. It was never assumed that the consent decree controls were BART and that a full BART analysis was not necessary. Therefore, a full BART analysis was performed.

3.2 Target Emissions

The NPS indicates that the BART analysis should have been performed for a NO_x emission rate of 0.05 lb/MBtu for the SCR control technology case.

The NPS provided NO_x emissions data for units with retrofitted SCRs. This data was taken from the EPA's Clean Air Markets database. These examples show average emissions of between 0.05 and 0.06 lb/MBtu. The units in question are OTAG units, meaning they run their SCR during the Ozone Season only (May through September). These plants turn off their SCR's for the remainder of the year. The NPS indicates that because these maintained an emission rate below 0.07 lb/MBtu, that the BART SCR technology for SJGS should have been performed at 0.05 lb/MBtu. However, these units are not directly comparable to SJGS for the following reason:

- Ozone Season Units Versus Full Year Operation. The SCR's for these units only run five months out of each year. Therefore, if the plant needs to make a certain NO_x emissions limit, they can run the SCR as hard as possible with less regard for maintenance and/or long term reliability. The systems on these units only need to operate until the end of the ozone season, after which, the SCR systems can be brought off line. The catalyst can be inspected and cleaned, and the ammonia system and NO_x monitoring system can be refurbished and repaired at the plant's leisure to prepare for optimal SCR performance in the upcoming ozone season. These plants are not under the same pressure as SJGS would be to meet a permit emission limit year round.
- Yearly Tons Limit Versus Emission Rate Permit Limit. The NPS provided graphs of the NO_x emissions for each of the ozone season SCRs discussed in their letter. As illustrated in NPS's own graphs, EVERY unit had exceedances above the 0.05 lb/MBtu emission rate. The ozone season units do not have a permit limit of 0.05 lb/MBtu. Instead, they are allocated a yearly amount of credits (tons of NO_x) that can be emitted from their unit. Therefore, if they exceed their target emission rate for a period, they can easily make up for the exceedance by operating at low load after the problem is corrected. These units have the entire ozone season to make up for operational problems that may cause minor exceedances in operation. SJGS will not have this luxury on flexibility. SJGS will be limited by a permit that requires them to meet their permit limits all year.

Additionally, the NPS also indicates new unit SCR's with permit emissions limits of 0.06 lb/MBtu (Desert Rock) and 0.05 lb/MBtu (FPL Glades). It should be noted that neither of these units are in operation and have not yet been proven that they can meet these permit values. In addition, the FPL Glades project was not

approved by the local utility commission. As a result, that project is cancelled. As previously noted, there are inherent differences between a new unit and a retrofit unit. To reiterate these important facts, in the case of a new unit, the SCR can be designed for optimum performance with long residence times. The boiler outlet duct can also be designed for an optimum SCR arrangement. On an existing unit, the ability to install an “ideal” arrangement is limited by the existing plant and unit specific conditions and restrictions. This is especially true of SCR retrofits. SCRs are located between the economizer and the air heater (or in the case of PNM, between the ESP and the air heater). This is a very congested area of the plant. Plant equipment (such as fans, boiler support steel, ESP support steel, underground utilities, and air heater maintenance steel) restrict the possible ductwork arrangements. Since SCR performance is highly dependant on having even flow distribution into the ammonia injection grid and the catalyst, the 0.07 lb/MBtu emission rate reflects the limitation associated with retrofit SCR's and specifically the limitations at SJGS.

Finally, although there are some new units being permitted at 0.06 lb/MBtu, there are also new units being permitted at 0.07 lb/MBtu, as previously shown in Table 2-1. Therefore, even among new units, there is industry uncertainty associated with what value represents an appropriate NO_x emission limit for an SCR system. There are fuel and technology considerations for these units that resulted in specific PSD NO_x emission limits. As such, we have undergone similar analysis which resulted in a 0.07 lb/MBtu limit.

The above discussion supports using a 0.07 lb/MBtu NO_x emission rate in the PNM BART analysis. It is appropriate for a retrofit unit. It is appropriate for a unit that will be limited by a permit for its operation, and it is appropriate for a unit that will be required to operate its SCR all year round.

3.3 SCR Vendor Quotation

In NPS's letter, they include the following sentence”

“While all of this may be true with respect to SJGS, it was not discussed in the BART analysis, and should be supported by an engineering analysis by a SCR vendor.”

Black & Veatch, an engineering and construction company, developed the SCR estimate and considers this estimate competitive in the current SCR market. B&V's SCR experience includes performing detailed SCR design for over 20 SCRs. B&V has provided performance guarantees for 12 SCRs and provided proposals with performance guarantees for many other SCR projects in the past 5 years.

3.4 Visibility Metrics

NPS indicates that the visibility improvements for all 16 Class 1 areas should be added together. Then a \$/dv improvement should be calculated from total dv value.

This calculation would not be consistent with the BART rule and further removes the direct link between deciviews and what an observer sees. For example, suppose that there was a delta dv of 0.5 at each of the 16 Class I areas. The total for all the improvements would be a dv of 8. With the NPS logic, the proposed emission changes would produce total dv change of 8 which sounds significant. But any one observer at any one Class I area would only experience a delta dv of 0.5 - which should be generally imperceptible. So while 8 sounds like a lot of dv's it would make an imperceptible change to any one observer in any one Class I area. The point is that adding dv's across separate Class I areas could effectively multiply the threshold metric by the number of Class I areas which changes the basic "science" of visibility perception thresholds.

Another way to examine this concept is to look at what would happen if, for example, the Weminuche Wilderness had been designated as two Class I wilderness areas instead of one. Then according to the additive method a given reduction in emissions would be twice as cost effective. To change the cost effectiveness, one would only have to administratively divide a Class I area into subunits to individual model receptors. This makes the science totally dependent on an administrative decision.

Finally, it is not appropriate to add the deciviews across the 16 Class I areas because the maximum daily deciview impacts at each Class I area for the three year period modeled do not occur on the same days. On any single calendar day, which is the time period used in BART modeling analyses, the sum of the visibility impacts would be considerably less than adding up the maximum impacts as proposed by the NPS or FS because when a maximum impact occurs at one Class I area, then it is very likely there would be no impact at all at another Class I area located in the opposite direction from the facility. The meteorology does not allow all Class I areas to be affected simultaneously. Adding the maximum impacts obtained for each Class I area across the entire three year modeling period changes the statistical basis of the analysis and decouples the result from what actual observers would perceive.

For all of the above arguments, the use of a total dv improvement is not consistent with the BART rule.

3.5 Cost Effectiveness Metric

NPS compares the results of the NO_x cost effectiveness (in \$/ton) to a BART analysis for SO₂. The \$/ton value calculated for Tennessee Eastman plant in Kingsport, TN was for SO₂ scrubbers. This \$/ton cannot be compared to a \$/dV for a NO_x control technology.

The NPS letter also discusses the use of the OAQPS manual for cost development and a tool called "Cost Tool", developed by the EPA in 1997.

A review of the OAQPS calculations performed by NPS indicated several variances in assumptions used such as the number of SCR reactors (1 in the NPS OAQPS model calculations vs. 2 by B&V because of unit layout), the catalyst life, the need for draft

system modification, and the need for air heater modifications. However, more important than these difference in assumptions is the basic differences between the OAQPS method and B&V's method for developing costs. The OAQPS manual method of estimating utilizes an equation that starts with basic plant parameters, such as flue gas flow rate, emissions reduction, and catalyst volume to develop a generic price. The values for these parameters are multiplied by "indicative" factors to determine an overall SCR price. The method does not take into account the site conditions, underground utilities, draft conditions, air heater conditions, construction laydown areas, changes in the cost structural steel, or individual market construction labor rates.

For the cost estimates developed in the SJGS BART analysis, B&V performed an initial layout of the SCRs, determined preliminary structural steel column, fan, and reactor box locations to estimate of the quantity of ductwork required. Additionally, project specific balance of plant requirements for this site were also considered. The condition of the existing draft system was also assessed. This method of cost estimate development is project specific and significantly more accurate than the "indicative factors" approach utilized by the OAQPS manual method and is reflective of the current air quality control retrofit market. Therefore, the resultant estimate is competitive in the current SCR market.

A review of the cost estimates using "Cost Tool" program discussed by the NPS indicates that capital costs for SCR at SJGS is approximately 80 \$/kW. In 1997, there was only one SCR installed on a new unit (not a retrofit) in the entire US (OUC Stanton). Since then, the early estimates of SCR costs have been shown to have dramatically underestimated the true cost of SCR. In fact, many of the early SCR projects encountered financial difficulties because of these low estimates. Since then, a more accurate picture of the true cost of SCRs has been established. As a result, this tool is not a suitable reference for SCR costs when reviewing this BART analysis.

3.6 Use of Mobetec ROFA System

In Section 4.1 of the SJGS BART analysis, a discussion of the consent decree combustion control technology as state-of-the-art was made in addition to technical reasons why the NO_x presumptive level established for subbituminous coals is not relevant for SJGS.

ROFA was not considered as technically infeasible. ROFA was classified as a variant of overfire systems, which is being installed for the consent decree upgrades. The ROFA vendor, Mobotec, estimates ROFA to potentially have slightly higher performance than standard OFA systems. However, the presumptive level would still not be reached. Therefore, this technology is still considered technically infeasible.

The difference in applying a combustion related type technology between a 75 MW boiler and a 500 MW boiler is optimizing the urea injection system to achieve the required reagent distribution for the reduction process. While the vendor has provided a guarantee that this can be done on a 75 MW boiler, this guarantee does not apply to a 500 MW boiler, which will require a separate analysis/optimization to determine the

effectiveness of the reagent for reduction. The urea has to be injected in a very specific temperature zone, between 1500 F and 2200 F. In a small boiler, this temperature can be accommodated by one or two injection locations. However, in a larger boiler, many injection locations are required to ensure that the proper injection location is achieved at all loads. The need for additional controls needed for load changes on large units raises significant uncertainties regarding the performance capability on a larger unit.

MN Power Taconite Harbor installation of Mobotec multi-p technologies is still very new, since it was installed in mid-2007 with no long term operating/emissions data yet to substantiate the pollutant reductions indicated here. As discussed above, the expected performance guarantees provided by the vendor is specific to this application/boiler configuration.

3.7 PM BART

NPS indicates in a letter dated August 16, 2007 that the particulate emission limit should be reduced to 0.010 lb/MBtu, compared to the 0.015 lb/MBtu emission limit that will be achieved as part of the Consent Decree. NPS suggests that the fabric filter could be enlarged to achieve a lower particulate emissions rate.

As previously discussed, the consent decree equipment including the fabric filter is being installed on Unit 4 with the installation on the other units in the near future. The fabric filters are fully designed. The fabric filter can not just “be enlarged”. The cost effectiveness of re-designing and fabricating new fabric filters simply does not make sense when PNM is already making significant reductions in particulate emissions.

It should also be noted that comments made by the Forest Service indicates that the 0.015 lb/MBtu emission level for filterable PM is acceptable for BART.

4.0 Responses to Forest Service Letter

This section of the document is written in response to the comments received by the Forest Service. The Forest Service comment is written, followed by PNM’s response.

Forest Service Comment: We find it interesting that the addition of selective catalytic reduction technology (SCR) for NO_x would result in a further increment of significant visibility improvement at Pecos and San Pedro Parks. NMED should further evaluate its applicability under BART especially in light of the suggestion by the NPS that even greater improvements may be possible than were considered in the analysis.

PNM Response: Please see responses to the NPS letter in Section 3.2.

Forest Service Comment: We do not accept the use of the average deciview improvement for 16 Class I areas to determine cost effectiveness of the SCR technology. We believe that the fact that SJGS is impacting 16 Class I areas should be used to weight the impact analysis rather than to dilute it. Our review indicates that significant

improvements can be achieved at 8 Class I areas through the SCR NO_x reductions. Three Class I areas would see greater than 1 deciview of improvement, including San Pedro Parks.

One approach to determining cost effectiveness might be the average improvement at those 8 Class I areas where greater than 0.5 deciview improvement is possible times 8 (the number of significantly impacted areas). By our calculation the factor would be 7.269 rather than 0.6. We would also support the total impact factor as suggested by the NPS. We agree that cost effectiveness should be based on \$/dv.

PNM Response: Please see responses to the NPS letter in Section 3.4.